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# WAVELET BASED CT AND MRI IMAGE FUSION USING GUIDED FILTER

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**Abstract:**
After the registration of source images, images are separated into Low-Low (LL), Low- High (LH), High-Low (HL) and High-High (HH) frequency coefficients using Wavelet Transform. To de-noise the high frequencycoefficients Laplacian filter is used, weight maps determined by comparing not only low frequency coefficients but also high frequency coefficients at pixel level, for Guided Filter (GF) weight maps are applied as input images and low frequency coefficients as guidanceimage, for smoothing weight maps GF is used. Using LL and LH, HL and HH frequency coefficients and refined weigh maps, new frequency coefficients are computed by the weighted fusion algorithm. By the application of inverse transform low and high frequency coefficients are fused.

Key words: Registration, Guidace Filter, Laplacian Filter, Weight maps and Guidance image

## 1. Related works

The modality Computer Tomography (CT) provides the hard tissue information where as Magnetic Resonance Image (MRI) gives the soft tissue information in human body. Medical images are fused with the help ofGuided Filter (GF) method, for GF low frequency coefficients applied as guidance image and weight maps $W_1$ and W2 applied as source image, GF is used to smooth $W_1$ and $W_2$. Using Low (LL) and high (LH, HLand HH)frequency component and refined weight maps calculated by the weighted fusion algorithm. In proposed method only low frequency coefficients considered to determination of weight maps [1]. Images are fused using GF, the inputs for the GF may be the guidance image or any other image, guidance filter has the ability to smooth images while preserving the edges [2].In various applications the guidace filter is used like image enhancement [3], Noise reduction in images [4], Dehazing of images [5], and fusion of images [6]. Based on dual filter algorithm source images are fused in which both low and high frequency coefficients are taken in to considerations for the calculation of weight maps, but the algorithm is tested only with one dataset. To measure the performance of algorithm, the proposed method need to test by using the multiple data set [7]. A method is proposed based on the Dual Tree DWT that combines the source images and the resultant image provides improved image visual quality for further processing, The limitations of conventional DWT such as shift- invariance and directional selectivity are prevail over based on the Dual Tree DWT, in this article secrete sharing threshold is utilized to give authentication and privacy to secrete image [8].

Have anticipated techniques of image fusion based on continuous wavelet transform in place ofconventional discrete wavelet transform. Shown image fusion ways grounded on CWT provides better results when compared to discrete wavelet transform and discrete wavelet packet transforms [9].

Explained the significance of image fusion and resultant image obtained in fusion process called hybrid image that consistsspatialdata by protecting required quality of spectral information [10].The most recent image GF is proposed [11][16]. GF has capability to keep edge of an image and remove image noise. Limitation in bilateral filter similar as the edge grade inversion is overcome by GF. The topmost advantage of method is that complexity of method is direct, window size related and effectiveness is high. An algorithm is proposed to fuse CT and MRI images grounded GF.

Bilateral Filter (BF) is analogous to that of GF which that constructs grounded on Gauss filter [12]. It preserves image edge by filtering the noise, grounded on this property BF is applied different aspect of image processing. The input and guidance image of the BF is same. In recycling veritably frequently we bear for getting information from source image that needs another image to designkernel of filterin such a way it is consider asguided portionin image information.Common BF[13] the source and guidance image are distinct images, weight of kernel weight of filter is reckoned by content of redundant guidance image. Though, some drawbacks in BF and common BF, for operation of detail enrichment, there's observable boundary grade inversion [14].Proposed by Qi Sun [15].Intuitionist fuzzy interference method which is used to fuse the medical images.

## 2. Proposed Scheme.

2.1 Schematic of CT and MRI images fusion [7]

After source images registration, wavelet transform is apply to two images, that separates CT image into a low frequency ( LL)coefficient and 3 high frequency (LH,HL and HH) coefficients similarly MRI image separated into in to a low frequency ( LL) coefficient and 3 high frequency (LH,HL and HH) coefficients.

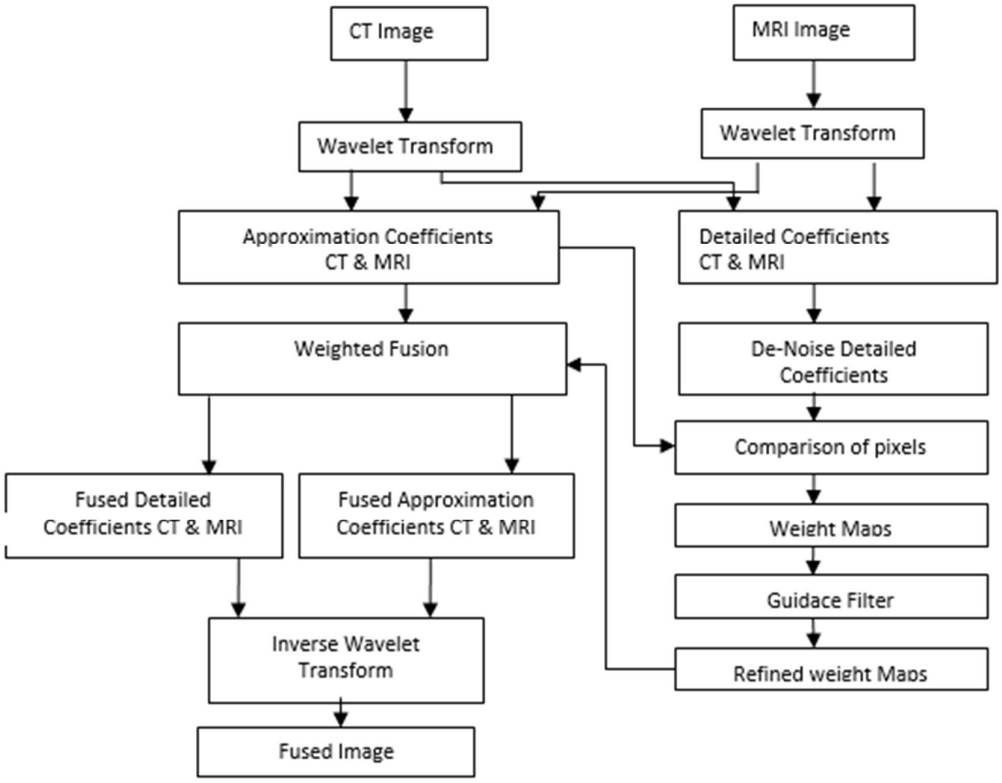



**Figure 1: Block diagram of proposed algorithm**

For removing noise from high frequency coefficients Laplacian filter is used. Weights$W_1$, $W_2$ attained by comparison of pixel values of low and highfrequency coefficient that is

$W_1$= Maximum ($A_1$,$H_1$, $V_1$, $D_1$)(1)

$W_2$ = Maximum ($A_2$, $H_2$,$V_2$, $D_2$) (2)

Where $A_1$,$A_2$ LL component of CT and MRI images respectively, $H_1$, $V_1$, $D_1H_2$, $V_2$, $D_2$ are LH, HL and HH components of CT and MRI images respectively.

Weights $W_1$and $W_2$smoothed by GF that are served as source image and related coefficients $A_1$ and $A_2$ serve as the guidance image, GF is used to upgrading weights and induce updated weights that are called as refined weights $M_1$ and $M_2$

$M_1$= $G_{r,\varepsilon}$ ($W_1$, A1)(3)

$M_2$=$G_{r,\varepsilon}$($W_2$,A2)(4)

Where r andεare considerations which computes size and blur degree of GF independently. Using weighted fusion method,fused low and high frequency coefficients are attained, $A_1$ and $A_2$ are used to calculate the fused LL component A and6 wavelet coefficients $H_1$, $V_1$, $D_1$, $H_2$, $V_2$ and $D_2$ are used to find3 fused LH, HL and HH components.

$$\left.\begin{aligned} A &= A_1 \ X \ M_1 + A_2 X \ M_2 \\ H &= H_1 \ X \ M_1 + H_2 \ X \ M_2 \\ V &= V_1 \ X \ M_1 + V_2 X \ M_2 \\ D &= D_1 \ X M_1 + D_2 \ X \ M_2 \end{aligned}\right\} \quad (5)$$

**2.2Assessment parameters**

To assess the performance of proposed method, resultantimages are analyzedusing assessment parameters such as SD,AG and ES. Consider testimage of size withM number of rows and N number of columns of source image individually.

**Standard Deviation (SD):**To compute spread in data SD is used which is denoted by σ, higher value of variance means high discrepancy of image also lower value of variance means low discrepancy of resultant image

$$\sigma = \sqrt{\frac{\sum_{i=0}^{A}\sum_{j=0}^{B}(If(i,j)-\mu)^2}{AB}} \qquad (6)$$

Where A is number of rows, B is number of column, variance denoted byμ and resultant image indicated by IF.

**Average Gradient (AG):**Spatial resolution of resultant image is reckoned by Average Gradient,higher value of AG explain fused image is of superior spatial resolution

$$G = \frac{1}{n}\sum\sqrt{\left(\Delta I_x^2 + \Delta I_y^2\right)/2} \quad (7)$$

**Edge Strength (ES):**Normalized performance of resultant image as per the source image is determined by ES. It is a Sobel edge Operator, Advanced value of ES indicates better edge information

$G = \sqrt{(G^2_x + G^2_y)}$(8)

**3Results and discussion**

Proposed algorithm is tested with five different data sets qualitatively and quantitatively, according to the fig.1 the fused image is most clear and strong sense of hierarchy when compared to the CT and MRI images.

For group 1: As per the fused image of group one it is much clear when compared to the source images, according to the table 1, SD, AG and ES are 0.2059, 0.2597 and 0.0539 respectively that are improved compared to the existing algorithm

For group 2: According to the intertwined image of gathering two it is a lot of clear it protects the integral and definite data of source images, according to the table 1, SD, AG and ES are 0.2100, 0.1917 and 0.0401 individually that are worked on contrasted with the current calculation

For group 3: According to the intertwined image is the most clear then, at that point, string feeling of progressive system, according to the table 1, SD, AG and ES are 0.2257, 0.3023 and 0.0641 individually that are worked on contrasted with the current calculation

For group 4: According to the intertwined image of gathering three it is a lot of clear it protects the integral and definite data of source images, according to the table 1, SD, AG and ES are 0.2594, 0.2514 and 0.0516 individually that are worked on contrasted with the current calculation

For group 5: According to the intertwined image of gathering three it is a lot of clear it protects the integral and definite data of source images, according to the table 1, SD, AG and ES are 0.2648, 0.3300 and 0.0681 individually that are worked on contrasted with the current calculation

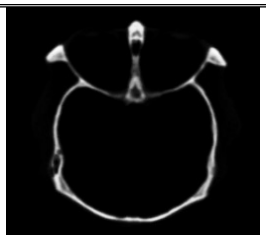
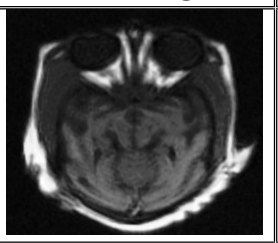
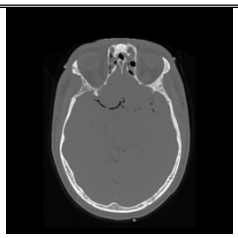
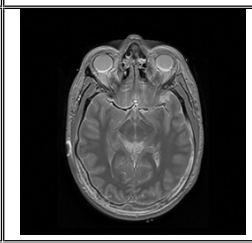
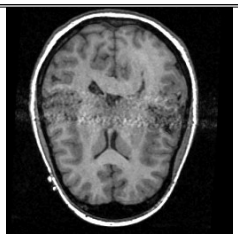
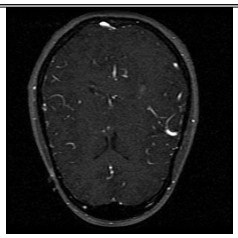
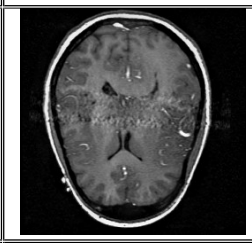
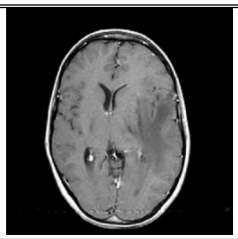
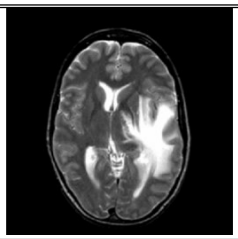
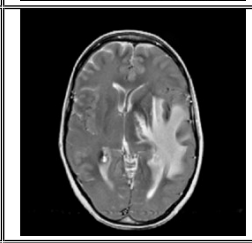
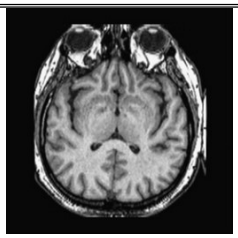
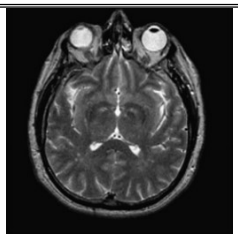
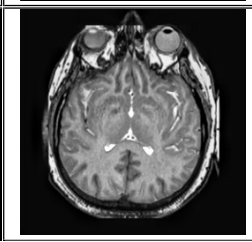
| Group | CT Image | MRI Image | FusedImage |
|---|---|---|---|
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

**Figure 2:Test images of group 1, 2,3,4 and 5**

**Table 1** Metric of fused image using GF based–images fusion method for input medical images [1] and proposed algorithm. The proposed dual filter algorithm is tested with five distinct data set and in all five data set it is provided better results compared to the existing algorithm.

| Data Set | Algorithm | SD | AG | ES |
|---|---|---|---|---|
| 1 | GF Based algorithm (Existing) | 0.1506 | 0.2489 | 0.0438 |
| | Proposedalgorithm | 0.2059 | 0.2597 | 0.0539 |

| | | | | |
|---|---|---|---|---|
| 2 | GF Based algorithm (Existing) | 0.2076 | 0.1420 | 0.0297 |
| | Proposed algorithm | 0.2100 | 0.1917 | 0.0401 |
| 3 | GF Based algorithm (Existing) | 0.2142 | 0.2364 | 0.0499 |
| | Proposedalgorithm | 0.2257 | 0.3023 | 0.0641 |
| 4 | GF Based algorithm (Existing) | 0.2278 | 0.1704 | 0.0348 |
| | Proposedalgorithm | 0.2594 | 0.2514 | 0.0516 |
| 5 | GF Based algorithm (Existing) | 0.2221 | 0.2190 | 0.0453 |
| | Proposedalgorithm | 0.2648 | 0.3300 | 0.0681 |

**Conclusion:**

In proposed algorithm a low (LL)frequency and three high frequency (LH, HL and HH) coefficients are attained by operation of DWT on CT and MRI images singly, presented in this research articlethat GF is used $W_1$ and $W_2$ served as source image and the corresponding LLfrequencycoefficients served as guidance image. Refined weight maps of source images are distinct and computed baseuniqueness of image that to be fused which are reckoned by not only comparing the low frequencycoefficients pixel by pixel but also with the high frequencycoefficients, Modified weights attained using GF which smooth the same, the low and high frequencycoefficients fused together by updated weights, A fused image of source images is attained using inverse transformation. Based on the comparison analysis of proposed algorithm it is conclude that resultant image is clear and more save the details of input images for multiple data sets.

**References**

1. Yan Na, Li Zhao, Yingxue Yang, MengqiaoRen, “Guidace filter-based images fusion algorithm for CT and MRI medical images”, IET Image Process., 2018, Vol. 12 Iss. 1, pp. 138-148

2. He, K., Sun, J., Tang, X.: ‘Guidace image filtering’, Pattern Anal. Mach.Intell., 2012, 35, pp. 1397–1409.

3. Fang, S., Yang, J., Cao, Y., et al.: ‘Local multi-scale retinex algorithm basedonguidace image filtering’, J. Image Graph., 2012, 17, (7), pp. 748–755

4.Liu, N., Zhao, D.: ‘Detail enhancement for high-dynamic-range infraredimages based on guidace image filter’, Infrared Phys. Technol., 2014, 67, pp.
138–147

5. Lin, Z., Wang, X.: ‘Dehazing for image and video using guidace filter’. 2012World Congress on Engineering and Technology, Beijing, China, 2012, pp.123–127

6. Li, S., Kang, X., Hu, J.: ‘Image fusion with guidace filtering’, IEEE Trans.Image Process.,

2013, 22, (7), pp. 2864–2875
7. M.N. Narsaiah, S. Vathsal, and D.Venkat Reddy "Dual Filter Based Images Fusion Algorithm for CT and MRI Medical Images" International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-9, July, 2019
8. P. Devaki,; and Dr. G RaghavendraRao. "A novel algorithm to protect the secret image through image fusion and verifying the dealer and the Secret Image" IEEE.Fifth International Conference on Signal and Image Processing, 77-80, 2014.
9. Qing X, Shuai X, Bing T &Jiansheng L, "complex wavelets and its application to image fusion", 20th ISPRS Congress, (2004).
10. Johnson Suthakar R, Monica Esther J, Annapoorani D &Richard Singh Samuel F, "Study of Image Fusion- Techniques, Method and Applications",IJCSMC, Vol.3, No.11, (2014), pp.469-476
11. He, K., Sun, J., Tang, X.: 'Guidace image filtering', Pattern Anal. Mach. Intell., 2012, 35, pp. 1397–1409
12. Tomasi, Y., Manduchi, R.: 'Bilateral filtering for gray and color images'. IEEE Int. Conf. Computer Vision, Piscataway, NJ, 1998, pp. 839–846
13. Petschnigg, G., Agrawala, M., Hoppe, H., et al.: 'Digital photography with flash and no-flash image pairs'. Proc. of the ACM SIGGRAPH Conf. ACM Transactions on Graphics, New York, NY, 2004, pp. 664–672
14. Durand, F., Dorsey, J.: 'Fast bilateral filtering for the display of high dynamicrange images: 'ACM transactions on graphics'. Proc. ACM SIGGRAPH Conf., New York, NY, 2002, pp. 257–266
15. Sun, Q., Na, Y., Liu, B.: 'Image fusion algorithm based on Mamdani intuitionistic fuzzy inference system', Electron. Sci. Technol., 2014, 27, (5), pp. 193.
16. M.N. Narsaiah, S. Vathsal "Medical Image Fusion using Different Wavelet Transforms" International Conference on Advances in Signal Processing and Communication Engineering, ICASPACE-2021, 29-31 July 2021, pp. 1-4.